APPARATUS FOR ISOLATING AND LEVELING A MACHINE FOUNDATION

The present invention is a continuation-in-part of U.S. Patent Application Serial No. 10/280,446 filed on October 25, 2002.

Field of the Invention

The present invention relates to machine foundations, and more particularly, an apparatus for isolating and leveling a machine foundation with respect to a substructure.

Background of the Invention

When installing and setting up heavy-duty industrial machinery (i.e., machinery, equipment, presses, etc.), it is difficult to properly isolate a machine from the substructure (i.e., floor, ground, etc.) of a building or facility or from the ground or soil of the earth. Such isolation may be desired to isolate vibration from a machine that is sensitive to vibration, as in the case of a magnetic resonance imaging (MRI) machine. In the alternative, such isolation may be required to isolate the vibration created by a machine from a substructure. The shock and vibration generated or realized by these machines may create misalignments of the machine due to the forces and the settling of the substructure or the machine's foundation. Proper alignment, including leveling, flatness, and the like, is essential in order to operate the machinery efficiently, economically and safely.

Prior designs have attempted to isolate a machine foundation from a substructure by providing a concrete well in the substructure. Sand or other fill materials line the walls of the concrete well and create a barrier between the machine's concrete foundation and the

substructure. Springs have also been utilized between the substructure and the machine's concrete foundation to isolate and support the machine foundation from the substructure. However, these designs do not provide a method or apparatus for easily and effectively leveling the machine.

Other past designs have utilized machine foundations that are integral with a substructure. Although some of these designs have provided leveling mechanisms between the machine and the foundation, the design of the machine foundation and the substructure must be completely re-engineered when replacing the existing industrial machinery. Re-engineering a machine foundation and a substructure is a costly proposition that is undesirable in the field of industrial machinery.

Thus, it would be desirable to provide an apparatus for isolating and leveling a machine foundation with respect to a substructure. It would also be desirable to have an apparatus for isolating and leveling a machine foundation wherein the apparatus and foundation could be reused with respect to a replacement machine.

Summary of the Invention

The present invention provides an apparatus for isolating a machine foundation from a substructure of a building while also providing proper adjustments to level the machine foundation. The apparatus of the present invention provides an enclosure connected to the machine foundation wherein the enclosure has an upper portion and a lower portion that are telescopically adjustable to one another to allow for various sizes of the enclosure and provide a leveling adjustment of the machine foundation. A bearing member is disposed within the enclosure and is adjustably connected to the enclosure. A support member is positioned

between and in connection with the bearing member and the substructure for isolating and leveling the machine foundation relative to the substructure.

The support member may include a substantially inner core fabricated from an elastomeric material. An outer layer overlaps the inner core wherein the outer layer is fabricated from elastomer-coated cords that resist radial expansion of the inner core in response to compressive forces along a longitudinal axis of the support member.

In another embodiment, the support member is fabricated from a high-strength, rigid material, such as a steel I-beam. The support member is adaptable to be removably disposed between the bearing member and the substructure so that the support member may be replaced with other support members.

In yet another embodiment, the support member is fabricated from an inflatable air bag for adjustably supporting the machine foundation. The air bag communicates with a conduit which extends through the enclosure and the substructure to communicate with a pressurized air source.

Brief Description of the Drawings

The description herein makes reference to the accompanying drawings, wherein like reference numerals refer to like parts throughout several views and wherein:

Fig. 1 is a sectional view showing the apparatus of the present invention being utilized to isolate and level the foundation of a MRI machine;

Fig. 2 is a cross-sectional view of the apparatus of the present invention taken in the direction of arrows 2-2 in Fig. 3;

Fig. 3 is a cross-sectional view of the apparatus of the present invention taken in the

direction of arrows 3-3 in Fig. 2;

Fig. 4 is a top view of the apparatus of the present invention;

Fig. 5 is a breakaway sectional view of an alternative embodiment of the resilient member and bearing member of the present invention.

Fig. 6 is a sectional view showing the support member of the present invention as an elastomeric inner core with elastomer-coated cords overlapping the inner core.

Fig. 7 is a sectional view showing the support member of the present invention as a steel I-beam.

Fig. 8 is a sectional view showing the support member of the present invention as an inflatable air bag.

Description of the Preferred Embodiment

Referring to the drawings, the present invention will now be described in detail with reference to the disclosed embodiments.

Figs. 1-5 illustrate the apparatus **10** of the present invention for isolating and leveling a machine foundation **12** with respect to a substructure **14** of a building (not shown) or the ground. As seen in Fig. 1, the apparatus **10** of the present invention may be used to isolate and level the machine foundation **12** of a machine **16**. The apparatus **10** may be utilized to isolate the vibration of a machine **16** from the substructure **14**, or the apparatus **10** may isolate the machine **16** from the vibration of the substructure **14** wherein the machine **16** is sensitive to vibration, such as in the case of a magnetic resonance imaging (MRI) machine installed in a hospital. The application of the present invention is not limited to MRI machines **16**, but rather, any large industrial machine which requires the isolation of vibration and shockwaves

and requires the leveling of a foundation may be utilized to isolate and level the machine foundation **12** from the substructure **14**.

The machine **16** is typically installed within a building by providing a concrete well **18** in the substructure **14** of the building. The machine foundation **12** is fabricated from concrete wherein the footings of the machine **16** are set in the concrete machine foundation **12** . A plurality of the apparatuses **10** of the present invention are set within the machine foundation **12** at strategically placed locations. For instance, the apparatuses **10** may be equally spaced within the machine foundation **12** and positioned at the corners of the machine foundation **12.** The machine foundation **12** is placed within the concrete well **18** of the substructure **14,** and a small space is created between the concrete well **18** and the machine foundation **12** by the apparatuses **10.** The apparatuses **10** utilize support members **20** and isolating members **22** to separate and isolate the machine foundation **12** from the substructure **14**. By isolating the machine foundation **12** from the substructure **14**, the apparatuses **10** provide a way to level the machine foundation **10** while also isolating vibration and shockwaves from the substructure **14**.

As seen in Figs. 2-4, the apparatus **10** of the present invention provides a substantially rectangular enclosure **24** that is set within the concrete of the machine foundation **12** and extends the entire depth or height of the machine foundation **12**. The enclosure **24** may also provide two cylindrical passageways or outlets **28** in the sides of the enclosure **24** that provide access to sidewalls **30** of the substructure **14**. It should be noted that the present invention is not limited to the enclosure **24** being substantially rectangular, but rather, the enclosure **24** may be constructed in any geometric configuration that will allow for the proper

isolation and leveling of the machine foundation **12**. In addition, the enclosure **24** may be fabricated from various materials. However, if the apparatus **10** is used in conjunction with a MRI machine, then a non-ferrous alloy, such as aluminum, should be utilized to construct the enclosure **24** so that the enclosure **24** will not affect the operation of the MRI machine **16.** A removable cover **31** covers the top of the enclosure **24** and is recessed just below the top surface **33** of the machine foundation **12**. The cover **31** should also be fabricated from a non-ferrous alloy if used in conjunction with an MRI machine.

In order to adjust the depth or height of the enclosure **24** to correspond to the depth or height of the machine foundation **12** , the enclosure **24** has an upper portion **32** and a lower portion **34** that are telescopically received within one another. Specifically, the upper portion **32** of the enclosure **24** is telescopically received within the lower portion **34** of the enclosure **24**. The upper portion **32** and the lower portion **34** of the enclosure **24** are adjustably connected through the use of three substantially right angle flanges **36** that are connected to and extend outward from the exterior of the upper portion **32** of the enclosure **24**. The flanges **36** each have an aperture extending through the outwardly extending portion of the flange **36**. The flanges **36** are equally spaced about the outer perimeter of the enclosure **24**. The lower portion **34** of the enclosure **24** has an anchor ring **38** integrally connected to the lower portion **34** of the enclosure **24**. The anchor ring **38** has an inner perimeter **39** and an outer perimeter **41** relative to the enclosure **24** that both extend at a substantially right angle from the lower portion **34** of the enclosure **24**. Three rods **40** are integrally connected to the anchor ring **38** and extend upward toward the flanges **36** of the upper portion **32** of the enclosure **24**. The three rods **40** correspond in location and number to the apertures in the

flanges **36** of the enclosure **24**. The rods **40** extend through the apertures provided in the flanges **36**, and three adjustable slip joints **42**, connected to each of the flanges **36**, receive and engage the rods **40**. The adjustable slip joints **42** provide a releasable locking mechanism that releaseably locks the rods **40** within the adjustable slip joints **42** and allows the upper portion **32** and the lower portion **34** of the enclosure **24** to telescopically move relative to one another to provide for the desired height of the enclosure **24**.

To apply the load of the machine **16** and the machine foundation **12** to the support member **20**, the apparatus **10** of the present invention provides a load bearing member **44**. The load bearing member **44** is a substantially flat, plate-like structure disposed within the enclosure **24**. Four threaded fasteners **46** connect the bearing member **44** to the inner perimeter **39** of the anchor ring **38**. The threaded fasteners **46** can be adjusted to adjust the distance between the bearing member **44** and the anchor ring **38**, thereby adjusting the load applied to the support member **20** and the distance between the machine foundation **12** and a floor **26** of the substructure **14.** However, the bearing member **44** can only be lowered to a point in which the upper portion **32** of the enclosure **24** bottoms out or engages the anchor ring **38**. This prevents the overloading of the support member **20**. It should be noted that the present invention anticipates other means of adjusting the distance between the bearing member **44** and the anchor ring **38** beside the fasteners **46**. For instance, hydraulic jacks may be utilized to adjust the height of the bearing member **44.**

The load of the bearing member **44** is applied to the support member **20** by having the support member **20** positioned between and in contact with a bottom surface **50** of the bearing member **44** and the floor **26** of the substructure **14**. The support member **20** may be a

substantially rectangular block of rubber material that allows for a certain amount of compressibility. This compressibility not only isolates the vibration and shock of the machine foundation **12** from the substructure **14**, but also allows for the adjustment of the fasteners **46** so as to level the machine **16** and its foundation **12**. The fasteners **46** can also adjust the vertical stiffness of the machine foundation **12** by compressing the support members **20** more to increase the stiffness and less to reduce the stiffness of the machine foundation **12.** Although the apparatus **10** of the present invention and the application thereof described may be best suited for a support member **20** fabricated from a rubber material, the present invention is not limited to the support member **20** being fabricated from a rubber material. The support member **20** may be fabricated from various springs, such as steel springs, or air bags. If the isolation of vibration is not a concern, then the support member **20** may be fabricated from a solid steel block in order to provide a more stable material for leveling the machine foundation **12**.

In an alternative embodiment, the structure of the support member **20** may be modified in order to stabilize the support member **20** by reducing the amount of horizontal movement of the support member **20**. As seen in Fig. 5, the support member **20** provides a recess formed in substantially the center of a top surface **56** of the support member **20**. The recess **52** may have a frusto-conical shape extending downward into the top surface **56** of the support member **20**. A complementarily engaging structure **57** is connected to the bottom surface **50** of the bearing member **44** through the use of a threaded fastener **58**. The complementarily engaging member **57** is connected to the end of a threaded fastener **58**. The threaded fastener extends through an aperture provided in the bearing member **44** and is secured to the bearing member **44** by the

use of a threaded nut **60**. The complementarily engaging member **57** has a frusto-conical shape which matingly engages the recess **52** provided in the top surface **56** of the support member **20**. As the load is applied through the bearing member **44** to the support member **20**, the complementarily engaging member **57** works to reduce the amount of horizontal movement of the support member **20**. The complementarily engaging member **57** may be fabricated from a rubber material similar to the support member **20** or may be fabricated from any other substantially high strength material.

The apparatus **10** of the present invention may also provide horizontal stabilizers **61** in order to stabilize the machine foundation **12** in a horizontal direction while also providing a stiffness adjustment along the horizontal or Y axis. In order to utilize the horizontal stabilizers **61**, the enclosure **24** is located relatively close to one of the sidewalls **30** of the substructure **14** so that the horizontal stabilizer **61** can engage the sidewall **30** of the substructure **14.** In addition, if the enclosure **24** is located within a corner of the machine foundation **12,** the horizontal stabilizer **61** may be utilized on adjacent sidewalls **30** of the substructure **14**, as seen in Fig. 4.

As seen in Figs. 2-4, the horizontal stabilizer **61** is disposed within the outlet or passageway **28** of the enclosure **24**. Since the horizontal stabilizer **61** engages the sidewalls **30** of the substructure **14**, the passageway **28** of the enclosure **24** has a longitudinal axis **64** that is substantially perpendicular to a vertical, longitudinal axis **65** of the enclosure **24**. The passageway **28** of the enclosure **24** is substantially cylindrical and provides an inner portion **66** and an outer portion **68** that are telescopically adjustable so that the length of the passageway **28** may be adjusted to correspond to the length of the machine foundation **12** that extends

between the enclosure **24** and an end of the machine foundation **12.** The inner portion **66** and the outer portion **68** of the passageway **28** have a slip joint feature that allows for easy telescopic adjustment of the inner portion **66** and the outer portion **68**. The telescopic arrangement of the passageway **28** is such that the outer portion **68** has a segment that is inside a segment of the inner portion **66** of the passageway **28**. It should be noted that the invention is not limited to a cylindrical passageway **28**, but rather, the passageway **28** may utilize any geometry that provides for a horizontal stabilizer **61,** as described in the present invention.

In order to horizontally stabilize the machine foundation **12**, four substantially rectangular tabs **69** extend radially inward from the inner circumference of the outer portion **68** of the passageway **28**. The four tabs **69** are spaced substantially 90° from one another. An anchor plate **70** has a substantially diamond configuration with four fingers **72** corresponding in position to the tabs **69** in the outer portion **68** of the passageway **28**. The anchor plate **70** provides a "twist lock" feature by having the four fingers **72** of the anchor plate **70** engage the tabs **69** on the outer portion **68** of the passageway **28** in a specific configuration. When the anchor plate **70** is rotated 45°, the four fingers **72** of the anchor plate **70** disengage the tabs **69** of the outer portion **68** of the passageway **28**. The anchor plate **70** provides a threaded aperture for threadably receiving a bolt or rod **76**, and a substantially cylindrical isolator plate **78** is connected to the end of the rod **76**. The isolating member **22** also has a substantially cylindrical configuration and is positioned between and in contact with the isolator plate **78** and the sidewall **30** of the substructure **14**. The rod **76** may be threadably adjusted with respect to the anchor plate **70** so that the amount of preload applied to the isolating member

22 by the isolator plate **78** may be adjusted by adjusting the length of the rod **76**. Threaded nut **79** secures the rod **76** in a predetermined position. The isolating member **22** is fabricated from a rubber material, but the isolating member **22** may also be fabricated from a spring or air bag.

In an alternative embodiment, the support member **20** may include a substantially cylindrical elastomeric member **90** that extends between the bearing member **44** and the floor **26** of the concrete well **18**, as seen in Fig. 6. The cylindrical member **90** provides a substantially cylindrical inner core **92** fabricated from an elastomeric material, such as rubber. The inner core **92** has a throughbore **94** coaxially aligned with a longitudinal axis **96** of the cylindrical member **90**. The throughbore **94** allows the inner core **92** to expand into the bore **94** of the cylindrical member **90** upon the realization of compressive forces along the longitudinal axis **96**. The cylindrical member **90** also provides an outer layer of elastomer-coated cords **98** that overlap the inner core **92**. The elastomer-coated cords **98** are spirally wound about the inner core **92** and are integrally bonded layer-to-layer to the inner core **92** wherein each layer of the elastomer-coated cords **98** are substantially parallel to one another and extend at an angle to the longitudinal axis **96** of the inner core **92**. The elastomer-coated cords **98** resist radial expansion of the inner core **92** in response to compressive forces along the longitudinal axis **96** of the elastomeric member **90**. The height of the cylindrical member **90** is such that the inner core **92** and the outer cords **98** have a height to width ratio of approximately 2:1 in an unstressed condition.

In yet another embodiment of the present invention, the support member **20** may be fabricated from a high-strength, rigid material, such as a steel I-beam **100**, as seen in Fig. 7.

The high-strength, rigid support member **100** is adaptable to be removably disposed between the bearing member **44** and the floor **26** of the concrete well **18** so that the rigid support member **100** may be replaced with other support members (not shown) should the need arise. The high-strength, rigid support member **100** may be utilized to support the weight of the machine foundation **12** wherein the isolation of vibration from the machine foundation **12** is not desired. Although vibrations from the machine foundation may not be isolated, the apparatus **10** of the present invention may still be utilized to provide the benefits of leveling the machine foundation **12**.

In even yet another embodiment, the support member **20** of the present invention may include an adjustable air bag or bellows **110**, as shown in Fig. 8. The air bag **110** is sealably mounted to the bearing member **44** and the floor **26** of the concrete well **18** and is in communication with a conduit **112** for communicating pressurized air to and from the air bag **110**. The conduit **112** extends from the air bag **110**, through the housing **24**, and into the machine foundation **12** wherein the conduit **112** communicates with a pressurized air source (not shown). Pressurized air may be supplied to and from the air bag **110** to provide an adjustable amount of pressure to the bearing member **44**. A gauge (not shown) may also be utilized to monitor and determine the air pressure within the air bag **110**.

In operation, the enclosure **24** is set within the concrete of the machine foundation **12**. The apparatuses **10** of the present invention are placed in strategic locations within the machine foundation **12** in order to properly isolate vibration from the machine foundation **12** to the substructure **14**, as well as provide specific leveling adjustments to the machine foundation **12**. In setting the enclosures **24** within the concrete of the machine foundation **12**,

the length of the enclosure **24** must be properly adjusted for the height or depth of the machine foundation **12** by adjusting the upper portion **32** and the lower portion **34** of the enclosure **24** through the use of the adjustable slip joint **42**. Once the enclosures **24** are set in the machine foundation **12**, the machine foundation **12** is placed in the concrete well **18** of the substructure **14**. The support member **20** is placed on the bottom of the enclosure **24**, and the bearing member **44** is secured to the anchor ring **38** through the use of the fasteners **46**. The fasteners **46** are tightened until a sufficient load is applied to the support member **20** such that the machine foundation **12** lifts off the floor **26** of the substructure **14**. Gauges or gauge pins **80** may be installed through corresponding apertures in the bearing member **44** and the anchor ring **38**. The gauges **80** extend to the floor **26** of the substructure **14** to determine the distance between the bearing member **44** and the floor **26** of the substructure **14**. The gauges **80** provide the user with an indication as to whether the machine foundation **12** is level. By reading the gauges **80** from all of the apparatuses **10** in the machine foundation **12**, proper adjustments may be made to the fasteners **46** in the bearing member **44** and the anchor ring **38** by lowering or raising certain areas of the machine foundation **12** so as to properly level the machine foundation **12**. In addition, the stiffness of the machine foundation **12** along the vertical axis **65** may be adjusted by compacting the support member **20** further if greater stiffness is desired and reducing the amount of compactness of the support member **20** if less stiffness is desired. The natural frequency of the machine foundation **12** can also be altered by adjusting the amount of vertical stiffness in the support member **20** or varying the amount of vertical stiffness among the various resilient members.

After the proper adjustments are made to the bearing member **44**, the horizontal

stabilizers **61** may be installed. The rod **76** along with the anchor plate **70** and isolator plate **78** are inserted into the passageway **28** of the enclosure **24**. The isolating member **22** is positioned between the isolator plate **78** and the sidewall **30** of the substructure **14**. The anchor plate **70** is inserted such that the four fingers **72** of the anchor plate **70** do not engage the tabs **69** located in the outer portion **28** of the passageway **28**. Force is applied to the anchor bolt **70** so as to preload the isolating member **22**. A sufficient amount of deformation of the isolating member **22** must occur to allow the anchor plate **70** to extend beneath the tabs **69** in the outer portion **68** of the passageway **28** in a locked position. The anchor plate **70** is then rotated 45° so that the four fingers **72** of the anchor plate **70** may engage the tabs **69** in the outer portion **68** of the passageway **28**. The bias from the isolating member **22** forces the anchor plate **70** against the tabs **69** so that a preload is applied and maintained against the sidewall **30** of the substructure **14**. The horizontal stiffness of the machine foundation **12** may be adjusted by threadably adjusting the length of the rod **76**. If a greater amount of horizontal stiffness is desired, the rod **76** is threaded outward toward the sidewall **30** of the substructure **14** such that the isolator plate **78** deflects or deforms the isolating member **22** to a greater degree. If a lesser amount of horizontal stiffness is desired, the rod **76** is threaded inward toward the enclosure **24** such that the isolator plate **70** decreases the amount of deflection or deformation to the isolating member **22**.

If the machine **16** is replaced with another machine (not shown), the machine foundation **12** and the apparatuses **10** may be utilized in conjunction with the new machine. The old machine **16** is removed from the machine foundation **12**, and the new machine is set within the machine foundation. Depending on the length of time the apparatuses **10** have been

in use, the support members **20** may need to be replaced with new support members (not shown) fabricated from the same or different materials as the previous support members **20,** depending on the application. The set up for the new machine is the same procedure as noted above.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to those disclosed embodiments, but to the contrary, it is intended to cover various modifications and equivalents arrangements included within the spirit and scope of the appended claims. The scope is to be accorded the broadest interpretation so as to encompass all such modifications on equivalent structures as is permitted under the law.